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Report No. 8926-141

Material - Adhesives - Ceramic for Bonding
Felted Stainless Steel Fibers

Bonding Feasibility

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Abstract;

Three different ceramic adhesives were used to attach 0.010 by 2 by 2 inch pieces of 17-7 PH stainless steel to 3/4 by 2 by 2 inch pieces of felted 17-4 PH stainless steel fiber pads. Firing temperatures of 1050 and 1750°F were used to effect the bonds. The application of force normal to the faces of the panels indicated the presence of good adhesion, since bond failures were of the cohesive failure type: peeling forces when applied resulted in ready separation of the face plate from the pad, thus indicating a lack of resistance to bending in the bond.

Reference: Pratt, D. S., Turner, H. C., Sutherland, W. M., "Ceramic Reinforcement and Bonding of 17-4 PH Stainless Steel Felted Fibers," General Dynamics/Convair Report MP 59-440, San Diego, California, 15 September 1960. (Reference attached).

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REPORT NO. MP-59-440

CERAMIC REINFORCEMENT AND BONDING OF 17-4 PH STAINLESS STEEL FELTED FIBERS

REA 8030

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OBJECT:

1. Investigate the feasibility of bonding cover skins to sintered fiber metal pads.

2. Investigate means of increasing the strength of sintered felted metal pads by using ceramic adhesives with emphasis on minimum weight increase.

CONCLUSIONS:

1. It is possible to bond cover skins to sintered fiber metal felt pads. It was not feasible in this limited test to determine the degree of bonding obtained. Testing by hand indicated a fair degree of bonding against a normal force but a low resistance to peeling forces.

2. The coating of the fine metal fibers with a ceramic seems to increase the stiffness of the pad. This increase was accompanied by a weight increase of 17% to 60%. This apparent increase in stiffness was not measured in any manner, but was estimated on the basis of finger pressure required to compress the pad.

RECOMMENDATIONS:

Additional laboratory investigation should be conducted to evaluate the following parameters:

1. Loads required for bonding.
2. Temperature of bonding.
3. Atmospheres required, if any, for the best bonding.
4. Techniques of application.
5. Properties of sandwich panels
    a) peel
    b) edge compression
    c) flatwise compression
    d) shear
    e) tensile strength
    f) insulation properties.

SPECIMENS AND PROCEDURE:

Eight pieces of sintered 17-4 stainless steel fiber pads, 2"x2"x3/8" were furnished by the Producibility Group. Cover skins were 2"x2" pieces of 17-7PH stainless steel of 0.010" thickness.

SPECIMENS AND PROCEDURE: (Continued)

The steps in chemical cleaning of both the pads and cover skins are listed below.

1. Vapor degreasing
2. Acid solution (180°F for 1-1/2 min. for pads, 10 min. for skins) 76% H_2O, 20% HNO_3, 4% HF
3. Running cold water rinse 5 min.
4. Oakite 90, 200°F for 10 min.
5. Running cold water rinse for 5 min.
6. Hot air dry.

Eleven ceramic adhesives had been formulated under a previous investigation. (See Report No. MP-59-110.) From these, two were possibly suited for this task. Formulations for these are given in Table I. In addition, a solution of colloidal silica was selected.

Six pads, 1, 2, 3, 4, 7 and 8,were selected for the application of the coatings. Two pads were to remain uncoated to serve as control pieces.

The adhesives were thinned to a specific gravity of 1.60 with water. Each adhesive was applied to two pads by dipping. The pads were dipped, suspended until the adhesive stopped dripping, then dried in a vertical position at 220°F for two hours. The weight of the dried adhesive retained in each pad and percentage of weight gained is shown in Table II.

All firing was done in a normal atmosphere. Pads 1, 2, 5, 6, 7 and 8 were fired at 1050°F for five minutes. Pads 3 and 4 were fired at 1750°F for the same period. As four of the six test panels, 1, 2, 7 and 8, required the 1050°F temperature to fuse the ceramic coating, the control pads 5 and 6 were also fired at this temperature.

A pair of skins was sprayed with a thin coating of each of the three adhesives applied to the pads. After drying for two hours at 220°F, the coatings measured 0.001"to 0.003" thick.

Pads 1, 4, and 8 were made into sandwich panels. Pad 1 had 8102 adhesive and was fired with a 15 psi compressive loading. Pad 4 and pad 8 were bonded to their skins with a 5 psi compressive loading. The pads 2, 3, 5, 6, and 7 were fired without the application of any weight.

RESULTS:

Pad 1, assembled as a sandwich with the 8102 adhesive, was reduced to about one-half of the original size with the 15 psi loading. The skins appeared well bonded when tested by pulling normal to the adhesive, but when forced from a corner, the skin came off easily. This failure appeared to be cohesive. When the skin was bent 180° and returned, the adhesive exhibited excellent adherence by showing very limited spalling. The adhesive on the pad flowed down into the pad from the top. The fibers on the outside of the pad were well coated with the ceramic and

RESULTS: (Continued)

appeared protected from oxidation. The fibers in the interior had severely oxidized pockets penetrating about half way through the fibers.

Pad 2 with the 8102 coating remained flat. The adhesive drained to the bottom edge as it dried and so formed a heavier concentration in the area. Small pockets of concentrated adhesive could be seen scattered through the sample. The general appearance was black-gray in color. The small concentrations of adhesive showed some oxidation protection, but the majority of the fibers oxidized in a manner similar to pad 1. This pad had a weight gain of 42.7%.

On pad 3, adhesive C2-1 formed many little points of concentration where the fibers intersected. These tended to stiffen the pad. No selective oxidation was seen. The fired pad had a 49.9% weight increase.

Pad 4,which was made into a sandwich, was coated with adhesive C2-1. This was fired at 1750°F with a 5 psi compressive load. This load reduced the pad to about one-half of its original thickness. As with pad 1, the skins appeared well bonded against a normal pull, but came off when pried from one corner. The failure appeared to be adhesive in nature. The ceramic formed many points of local reinforcement throughout the pad and produced a protective coating over every fiber. Where this coating had broken away from the fiber the exposed metal did not seem corroded. The small roughness seen is believed to be the result of the acid cleaning.

Pads 5 and 6 with no coating remained their original thickness when fired. They had a very thin oxide film on the wire. This film varies from a silver to golden brown in color. It was easily removed by redipping the pad in the acid cleaning solution.

Pad 7, coated with the colloidal silica, fired to a light gray and brown. The colloidal solution being very low in viscosity drained easily to the bottom edge while drying. This gave a heavy concentration of the silica on the lower edge. The fibers were uniformly coated with a film of silica and did not seem to be corroded. The silica film had formed local points of reinforcement where the fibers cross. This coating increased the pad weight 18.8%.

Pad 8, assembled as a sandwich, was very similar to pad 7. However, no adhesion was developed between the skins and the pad. There was no compression of this pad from the 5 psi compressive loading. In the areas where the silica glass broke away from the fiber, no corrosion was seen. The expansion of this glass is very low and as a result, many micro cracks developed when the pad was air quenched.

DISCUSSION OF RESULTS:

This investigation into the bonding of metal skins to sintered felted metal fibers and the stiffening of the pads had a limited degree of success while pointing out areas needing more investigation.

The degree of bonding reached with pads 1 and 4 show promise. The ceramic adhesives bonded to themselves and to the metals employed. The cohesive failure of the adhesive on pad 1 was most promising as adhesives generally are bonded much stronger to themselves than they do to other bodies.

Adhesive failure of pad 4 is the type most generally seen and expected in the failure of a glass to metal bonding operation.

Silica is a refractory material whose melting point is 3200°F. However, when this material is ground to colloidal size the melting point is approximately 1000°F. It was to take advantage of this feature that the material was selected. The thought was that the colloidal silica would melt at 1000°F and then form a higher melting point after cooling. The silica failed to bond, but there is a possibility that finer particle size will reduce the initial melting temperature of some of the other adhesives that do bond better.

NOTE: Data for this report are recorded on pages 147, 148 and 149 in Materials and Processes Laboratory Notebook No. 3029.

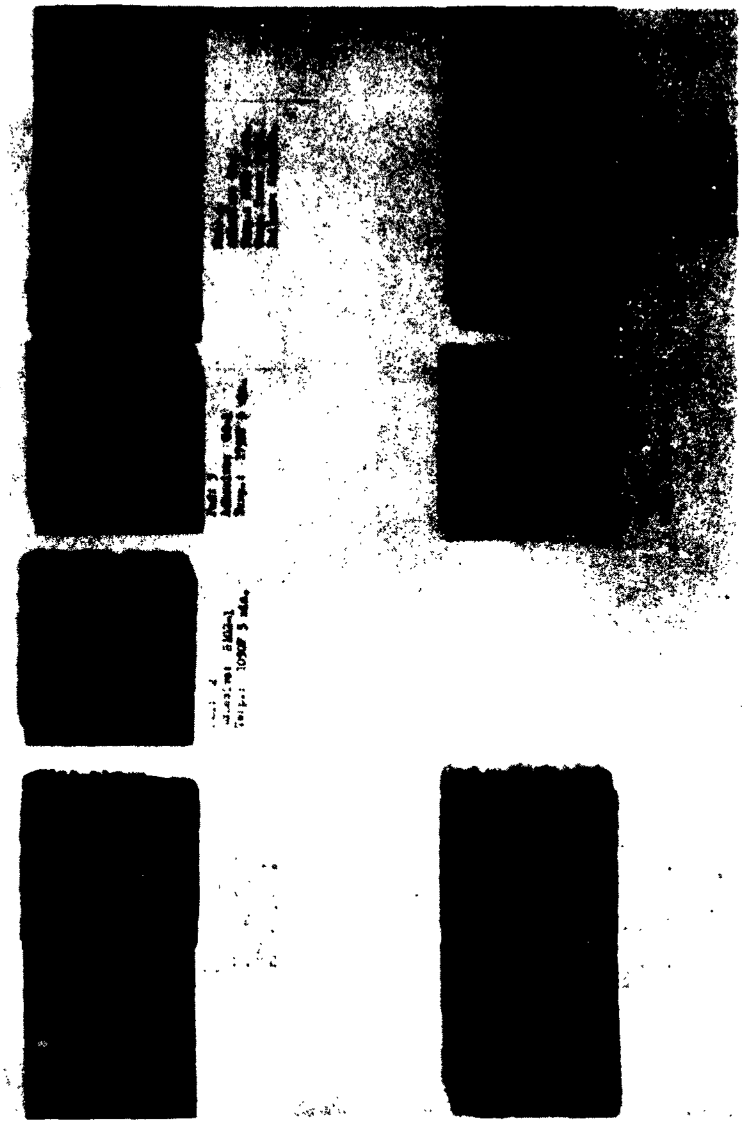

FIGURE 1. SINTERED METAL FIBER PADS AFTER TREATMENT.

TABLE IA

FRIT COMPOSITION, PARTS BY WEIGHT

Frit	Raw Materials		
	SiO_2	Na_2O	Li_2O
C2	73	22	5
8102	This is a commercial low melting frit. The composition is not available.		

TABLE IB

ADHESIVE SLIP FORMULATIONS, PARTS BY WEIGHT

	Adhesive	
Materials	8102	C2
Frit 8102	100	- -
Frit C2	-	100
Water	55	45
Mill Compound XB-87	2	- -

Specific gravity: 1.60; Fineness: Zero grams on a 325 mesh screen from a 50 cc sample.

TABLE II

PERCENTAGE OF WEIGHT GAINED FROM CERAMIC COATING

Pad. No.	Adhesive	Initial Clean Pad Weight	Clean Pad & Dried Adhesive	% Dried Wt.Gained	Method Pad was Used for Study
1	8102	5.45 gm.	7.06 gm.	29.5	Sandwich Panel
2	8102	5.91 "	8.50 "	43.75	Coating Only
3	C2-1	8.89 "	14.28 "	60.72	Coating Only
4	C2-1	8.23 "	12.59 "	52.97	Sandwich Panel
5	None	8.91 "		Control Piece	
6	None	8.87 "		Control Piece	
7	Colloidal Silica	9.66 "	11.50 "	19.01	Coating Only
8	Colloidal Silica	7.73 "	9.07 "	17.43	Sandwich Panel